METEOROLOGICAL ANALYSIS OF OCCURRENCE OF GROUNDED MIGRANTS AT SMITH POINT, TEXAS, APRIL 17 - MAY 17, 1951

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It is not at all clear to what extent and in what manner weather controls the migratory movements of birds. Some authorities belittle the influence of weather and place far more emphasis upon such factors as amount of daylight, degree of gonadal development, and inherited migratory urge. Others suppose spring migration to be regulated by the advance of temperature isotherms. Still others disagree with a purely mechanistic approach and believe that day to day changes in the weather play an important role in shaping the progress of migration.

This latter concept is the one favored by most recent writers (Robbins, 1949; Williams, 1950; Bagg *et al.*, 1950; Gunn and Crocker, 1951). Their findings clearly confirm the fact that weather does exert an influence upon migration, and, in many instances, show that birds respond to weather variations to a very marked degree. Not enough detailed studies are available, however, to permit students to say that birds always respond in the same manner to the same meteorological phenomena. As a slight contribution to our knowledge in this field I am now undertaking to interpret daily observations of the spring migration made by myself at Smith Point, Texas, in April and May of 1951.

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Study Area and Methods

Smith Point is a triangular shaped area of land which projects into Galveston Bay from the northeastern side. From the area where observations were made near the end of the point, it is 10 miles to the Gulf of Mexico while the metropolis of Galveston on the Gulf lies some 18 miles across the bay to the south. A strip of woods on the north side of the point was chosen as a suitable locality to make daily observations.

The low-lying woods, composed of hackberry, *Celtis* sp., and various xerophytic trees and shrubs, faces the bay to the north and open pasture land to the south. At the eastern end a narrow creek bordered by marshes separates the study area from another similar thicket to the northeast. Surrounded by water or grazing land, the thicket, stretching three-fourths of a mile along the bay and averaging about 50 feet in width, forms a natural haven for migratory land birds.

On April 17, 1951, I began taking census counts at the thicket. With the

exception of April 20, when it was impossible to be in the area, counts were made every day through May 17, 1951. Generally counts were conducted during the morning. No set length of time was prescribed nor was the thicket always traversed in exactly the same manner. When few migrants were present the thicket could be covered in less than an hour, but on certain days when large numbers of birds were present, it took as long as six hours to make a thorough coverage. Owing to dense foliage in places, it was a time-consuming process to make reasonably sure that all species, if not all individuals, were counted. On the whole, birds were easy to approach and it was possible to view them under good conditions for making identifications.

Not included in the counts were resident species and birds not definitely associated with the thicket. Thus the following residents found in the area were not included although migrant individuals, representing several of these species, undoubtedly passed through: Mourning Dove (*Zenaidura macroura*), Scissor-tailed Flycatcher (*Muscivora forficata*), Mockingbird (*Mimus polyglottos*), Red-winged Blackbird (*Agelaius phoeniceus*), Boat-tailed Grackle (*Cassidix mexicanus*), and Cardinal (*Richmondena cardinalis*). Not closely enough associated with the census area to be included were herons, hawks, gulls, terns, shorebirds, and swallows. The Savannah Sparrow (*Passerculus sandwichensis*) and the Dickcissel (*Spiza americana*), although often present in large numbers, were not closely associated with the area and so were not included. The Sora (*Porzana carolina*) on the other hand, was included when found taking refuge within the census area. The Blue-gray Gnatcatcher (*Polioptila caerulea*), a migrant which occurred in fair numbers during the first week or two, was mistakenly omitted.

Daily weather reports were obtained from the U.S. Weather Station at Galveston, and data from these have been used in compiling Table 2. For weather developments on a wide scale, frequent reference was made to the weather maps of the U.S. Weather Bureau. Admittedly there are local variations in the weather between Smith Point and Galveston, but these were not considered to be important enough to alter the conclusions arrived at in this study. My own temperature and barometer readings at Smith Point agree closely with those of the Galveston Weather Station, and no major inconsistencies in regard to wind direction or precipitation were detected.

Census Results

Table 1 gives the names of migrants seen in the census area, their numbers, and the dates on which they occurred.

The 52 species listed are migrants closely associated with the census area. The Wood Pewee, Eastern Kingbird, and Indigo Bunting were present on at least 16 of the 30 days in the study period. The Indigo Bunting was the most abundant species recorded. (Figures of 20 and over are estimates.) Of the

Table 1

Daily Counts in the Census Area, April 17—May 17, 1951

Species	April													May															
	17	18	19	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Sora rail, *Porzana carolina*								1													1									
Yellow-billed cuckoo, *Coccyzus americanus*														1							2	1			2	1				1
Black-billed cuckoo, *Coccyzus erythropthalmus*	1	1																												
Ruby-throated hummingbird, *Archilochus colubris*	1	1	1				1											1		1	6	2	2			1				
Eastern kingbird, *Tyrannus tyrannus*	8	1	1	1		1		2	2						12	3		2	2		10				1	1	2			2
Crested flycatcher, *Myiarchus crinitus*	4														2															
Unidentified empidonax, *Empidonax* sp.			1																		1				1					
Wood pewee, *Contopus virens*	1	1	1	1	1	2								3	10		2	4	2	4	6		2	3	2					
Catbird, *Dumetella carolinensis*	1					2	3							3	3			1				1								
Wood thrush, *Hylocichla mustelina*	1					5												2			2									
Olive-backed thrush, *Hylocichla ustulata*	1					1	1								1		1	2		1	8	1			4					
Gray-cheeked thrush, *Hylocichla minima*																	1	1		1	4									
Veery, *Hylocichla fuscescens*																					1									
Cedar waxwing, *Bombycilla cedrorum*																					1									
White-eyed vireo, *Vireo griseus*	3	3				1									2		1													
Bell's vireo, *Vireo bellii*																		1												
Yellow-throated vireo, *Vireo flavifrons*	1																													
Red-eyed vireo, *Vireo olivaceus*	3	5	3	3	3	3	3								1			1	1		2				2					
Philadelphia vireo, *Vireo philadelphicus*															1						1	1								
Warbling vireo, *Vireo gilvus*																		1												
Black and white warbler, *Mniotilta varia*	7	5	1	1		1									2			4			1	1								
Prothonotary warbler, *Protonotaria citrea*	1	1	1																											
Worm-eating warbler, *Helmitheros vermivorus*	1																													
Golden-winged warbler, *Vermivora chrysoptera*						1												1			1									

	17	18	19	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Tennessee warbler, *Vermivora peregrina*															1			3												
Yellow warbler, *Dendroica petechia*		2													2			2			10	3								
Magnolia warbler, *Dendroica magnolia*						1	1	1							20		1	12	1		2	1		1						
Myrtle warbler, *Dendroica coronata*										1				1	1															
Black-throated green warbler, *Dendroica virens*				1		1									1			4			2	1			1					
Cerulean warbler, *Dendroica cerulea*				1																										
Blackburnian warbler, *Dendroica fusca*															1			5	2	2	2									
Chestnut-sided warbler, *Dendroica pensylvanica*						1								2	2			4	1					1						
Bay-breasted warbler, *Dendroica castanea*										1					4			1	1		1	1								
Black-poll warbler, *Dendroica striata*																					1		1	1						
Ovenbird, *Seiurus aurocapillus*	2					2															2			1						
Northern water-thrush, *Seiurus noveboracensis*									1											1	1									
Louisiana water-thrush, *Seiurus motacilla*						1																								
Kentucky warbler, *Oporornis formosus*						1	1																							
Yellow-throat, *Geothlypis trichas*	2	2	1			3								2	6						1				1					
Yellow-breasted chat, *Icteria virens*	1		1			2											1	1								1				
Hooded warbler, *Wilsonia citrina*	6	1	1	1		4																								
Canada warbler, *Wilsonia canadensis*															1			1						1						
American redstart, *Setophaga ruticilla*	3					5	2		2	1					2		1	4	2		2	1			1					
Orchard oriole, *Icterus spurius*	6	4	5	12	1	5					1				4								2							
Baltimore oriole, *Icterus galbula*			1			2	1								2		1	2												
Scarlet tanager, *Piranga olivacea*		1					1																							
Summer tanager, *Piranga rubra*	2	1				1		1													1		1							
Blue grosbeak, *Guiraca caerulea*						1								2	2										1					
Indigo bunting, *Passerina cyanea*	60	20	17	20	20	40	20	7	7					5	20			20		8	20	4		5	3					
Painted bunting, *Passerina ciris*	1	1				1	2	1			1	1		2																
Lincoln's sparrow, *Melospiza lincolnii*					1																									
Swamp sparrow, *Melospiza georgiana*		1													1															

Table 2

Weather Conditions and Numbers of Migrants During Study Period

Date	Average temperature	Precipitation in inches	Prevailing wind direction	Average wind speed (m.p.h.)	Barometric pressure at 6:00 a.m.	Significant changes in wind and temperature	Numbers of species	Numbers of individuals
April 16*	63	.06	NE	16.7	30.00	Light SE before dawn. 38 MPH NNE at 6:00 a.m. changing to E before dark.	23	117
17	61	0	E	15.0	30.10	Shifting from NE to E during the morning	17	51
18	66	.01	S	9.0	29.88		13	35
19	70	0	SW	12.0	29.82			
20	67	.03	SE	12.3	29.91	A change from SE to ENE at noon	9	41
21	71	0	S	11.3	29.93	A change from SE to ENE at 6:00 a.m.	5	26
22*	75	0	N	11.2	30.01	Shifting from E to NNW during the morning	25	88
23	63	0	NE	12.7	30.21	Shifting from N to ESE during the morning	11	36
24	69	0	SE	13.1	30.11		6	13
25	71	0	SE	14.0	29.97		4	12
26	71	0	SE	12.8	30.06		3	3
27	71	0	SE	12.8	30.09		2	2
28	72	0	SE	12.3	30.08		1	1
29	73	0	SE	15.4	29.88		0	0
30	74	0	SE	21.3	29.75	Wind up to 31 MPH.		
May 1*	71	.12	SE	13.0	29.85	A change from SSE to NNW at 2:00 p.m. Temp. drop from 75 to 65 degrees between 3:00 and 4:00 p.m.	9	21
2	75	0	SE	10.9	30.03		25	104
3	75	0	S	10.6	29.98	Temp. rise of 9 degrees between 5:00 a.m. & 2:00 p.m.	1	3
4	79	0	NW	11.1	29.93	Shifting from SSW to NW before dawn. Maximum temperature of 88 degrees.	8	9
5	76	0	S	11.9	29.95	Shifting from NNE to E during the morning.	24	80
6	74	0	SE	13.3	29.88	Temp. rise of 8 degrees between 5:00 a.m. & 2:00 p.m.	8	12
7*	67	.66	NE	16.5	30.02	Shifting from ESE to NNE before dawn	7	18
8	70	.02	E	17.9	30.02	Shifting from NE to E before dawn	27	92
9	75	0	SE	14.3	29.98		12	18
10	74	.21	S	10.5	30.01	A change from SE to NW at 6:00 a.m.	5	8
11*	70	.13	NE	11.0	29.95	Shifting from W to NNE before dawn Shifting from NNE to ESE in afternoon	7	13
12	72	0	E	16.5	29.94	Shifting from NNE to ENE before dawn Shifting from ENE to ESE during afternoon	11	19
13	74	0	E	18.7	29.99		4	4
14	75	0	SE	21.0	30.05	Wind up to 36 MPH.	1	2
15	76	0	SE	23.0	30.10	Wind up to 33 MPH.	0	0
16	75	0	SE	17.9	30.16		0	0
17	75	0	SE	15.8	30.01		2	3

* Cold fronts penetrated region

warblers the Magnolia occurred in largest numbers, but the American Redstart was present on more days. Warblers and vireos are well represented in the counts by total species if not number of individuals. In comparison the sparrows are rather poorly represented. Absent or poorly represented are several early migrants. The Eastern Phoebe (*Sayornis phoebe*) was not recorded while the Myrtle Warbler was seen only three times. Also a number of migrants were recorded elsewhere in the Smith Point region during the study period but were not seen in the census area; among these are the Yellow-throated Warbler (*Dendroica dominica*) and the Pine Warbler (*Dendroica pinus*).

Table 2 shows several cause and effect relationships existing between number of migrants and weather conditions.

Cold fronts penetrated the region on April 16, and 22, May 1, 7, and 11. The arrival of a cold front is associated with northerly winds, lower temperature, higher barometric pressure, and, on four out of five occasions in my study, precipitation. The only increase in number of migrants not coincident with a cold front occurred on May 4. The significant weather conditions prevailing then were above-average temperature, westerly winds, and relatively low barometric pressure.

It is to be noted that migrants were *not* present in maximum numbers until the day after unfavorable weather had halted migration. After a peak had been reached, numbers declined steadily on each succeeding day of favorable weather. During the last week in April, a period of warm weather and southeasterly winds, the number of migrants declined on each day until on the 30th none at all were recorded.

A cold front on May 11 produced fewer migrants than usual. Presumably this was due to the fact that the peak of migration had passed.

Discussion

Arrival of migrants.—Unfavorable weather conditions may halt migration and result, in the terminology of Bagg, *et al.* (1950), in the presence of an "arrested wave." The opposite of this is an "onrushing wave" which occurs when birds begin moving with a return to weather conditions favorable for migration. At Smith Point, two contrasting meteorological phenomena were seen to result in arrested waves. Of six arrested waves noted during the period of observation, five occurred with the arrival of cold fronts and the sixth seemed to have been caused by a westerly wind.

Several Gulf Coast observers (Williams, 1945; Lowery, 1946) have commented upon the sudden and immediate appearance of migrants with the arrival of a cold front. At Smith Point the arrival of a cold front did not necessarily mean an immediate influx of migrants. Birds would arrive with the

first drop in temperature, but maximum numbers were not present until after the cold front had passed. Thus birds first arrive under weather conditions associated with a cold front. They continue to arrive with rising barometric pressure, warmer temperatures, and the first shift to a southerly wind.

That it takes as long as 24 hours or more for maximum numbers to appear following the arrival of a cold front seems explainable on the grounds that to the south conditions may still be favorable for migration, and thus birds flying over water or along the coast may continue northward even after a cold front has reached the vicinity of Smith Point. As they reach Smith Point, they tend to pile up in coastal thickets. As the coastline is largely devoid of habitat suitable for their needs, it seems likely that birds grounded in this inhospitable region tend to drift northward to wooded areas. Indeed, migrants at the census area, while awaiting favorable weather, restlessly made their way back and forth through the thicket, and some, usually after hesitation, crossed the creek at the eastern end of the thicket and flew to other patches of woods to the north. The creek seemed to act as a barrier, however, and tended to keep birds within the confines of the census area.

It was impossible to tell how long individuals stayed in the area, but there was evidence that some birds stayed as long as three or four days. A single Black-poll Warbler, a rarity along the Texas coast, was counted on three out of four days during the period, May 8 through 11. A Prothonotary Warbler, a species infrequently met with during the period of study, was seen on April 17, 18, and 19. A Philadelphia Vireo, perhaps the same individual, was seen on May 8 and 9.

Winds were from the northeast on four of the five occasions when cold fronts reached the Smith Point region. On May 1, a cold front brought northwesterly winds. The arrival of this cold front was of particular interest because it was in reality a quasi-stationary front which barely penetrated the Galveston Bay region. Immediately to the south a warm front was moving inland along the Texas Coast. On the morning of May 1, when a count was taken in the census area, the cold air-mass had not yet reached Smith Point. Only two migrant species were found, two Painted Buntings and one Myrtle Warbler. The temperature was 75° F., and the wind was from the southeast. At 2:00 p.m. the skies became overcast and the wind shifted to the northwest. Between 3:00 and 4:00 p.m., the Galveston Weather Station recorded a 10° drop in temperature. A fine rain accompanied these changes. I was in a wooded area some 10 miles north of the census area when the first indications of a change in weather became apparent. Migrants began to appear in the woods concurrently with overcast skies, northerly winds and falling temperature. On returning to the census area at 6:00 p.m., I found dozens of birds where in the morning there had been virtually none. Due to poor light

I had difficulty in identifying most of them, but I succeeded in adding seven species to the day's list. Late in the evening the wind shifted back to the southeast and by midnight the temperature had risen seven degrees. But as a result of this brief penetration of a cold air-mass, 25 migrant species were counted in the census area the following morning.

A Black-poll Warbler on May 8 is of interest since Williams (1950) associates the appearance of either this species or the Cape May Warbler (*Dendroica tigrina*) along the Texas coast with northeasterly winds. According to his view they are blown off course from their usual migration route through Florida. Weather conditions on the 8th seem to substantiate this explanation since on that date easterly winds prevailed all along the coast from Florida to Texas.

Arrested waves were associated not only with cold fronts but also, on one occasion (May 4-5), with a period of westerly and northwesterly winds not directly related to a cold front. It is to be noticed (see Table 2) that of six waves reaching Smith Point during the period of study, five were associated with cold fronts and the sixth, on May 5, was in no way associated with a cold front, but followed a period of westerly and northwesterly winds on May 4. The average temperature at Galveston on this date was 79° F., the highest for any day in the study period. Barometric pressure was low in the Galveston region, while the daily weather map for the 4th shows a high pressure area off the Texas coast.

In the events of May 4, we see an exception to the usual sequence of spring migration along the Gulf Coast of Texas. Instead of prevailing southeasterly winds, interrupted on the average of once every six days by the arrival of a cold front, we have westerly winds accompanied by unseasonably warm weather. That migrants should halt in the face of warm weather seems strange, but it appears in this instance that the wind was the controlling factor. With the wind striking them on their port beam, they were in danger, if they continued their flight, of being blown out over the Gulf.

Southwesterly winds on April 19, on the other hand, did not appear to bring a significant number of new migrants into the area. But in view of the fact that 13 species of migrants were counted on that date, it would seem that weather conditions were retarding departures. Ordinarily the exodus of migrants should have been all but completed three days after the passage of a cold front (on April 16). Unfortunately it was not possible for me to make a count on the 20th. If the southwesterly wind had been responsible for grounding an appreciable number of migrants, it might have been revealed by a census on that date.

Departure of migrants.—On departure, wind direction, temperature, and pressure trends are the reverse of conditions prevailing at the time of arrival.

Departures were made, as a rule, under conditions of southerly winds, rising temperature, and falling barometer. The only exceptions were (1) an occasion on May 13, when departures occurred with a rising barometer, and (2) on May 6, following an arrested wave which resulted from westerly winds when departures occurred with lower average daily temperatures.

Rising temperature seems to be the major factor in hastening departure so long as the wind is in a favorable quarter. Bagg *et al.* (1950) speak of "significant temperature-rise and a southerly wind as the meteorological key to the onrushing wave" during spring migration.

Tail winds.—It so happens that southerly winds go hand in hand with rising temperature and, therefore, birds generally leave in spring when a tail wind is blowing. This is in contrast to the behavior of resident species which almost invariably fly directly into the wind or else quarter into the wind when it is strong. When a moderately strong southeast wind was blowing on April 30, 1951, resident birds, without exception, were seen to avoid flying with the wind. On that date the Galveston weather station recorded a southeast wind with an average velocity of 21 m.p.h. A flock of White-faced Glossy Ibises, (*Plegadis mexicana*) was seen flying just above the waves out over Galveston Bay, and directly into the wind. Another flock of the same species flew parallel to the coast and at right angles to the wind.

It is probable that in cases such as the ones cited, birds near large bodies of water avoid flying with a wind which might take them out over a body of water. Similarly migrants, as seen in arrested waves in the face of westerly winds, avoid making flights when there is danger of their being blown out over water. With southeasterly winds migrants face no danger of being blown out over extensive bodies of water, and apparently obtain a distinct advantage in flying with the wind.

It is not clear, however, whether strong tail winds interfere with migration. But in view of the almost complete absence of migrants in the census area at Smith Point when southeast winds of up to 30 m.p.h. were blowing, it is safe to say that strong tail winds along the coast do not result in precipitations of migrants such as occur when a norther strikes. This is either because the birds continue on their course in spite of strong tail winds, or else because birds are simply not overhead to be grounded by adverse conditions. It does seem logical to suppose that continued strong southeasterly winds would tend to push the main current of migration inland.

Summary and Conclusions

From April 17 through May 17, 1951, daily census counts were taken in a thicket at Smith Point, Texas, with the purpose in view of determining how migrating birds respond to changes in weather conditions. During this period

birds were grounded in sizable numbers on six occasions. On five of these occasions the arrival of migrants coincided with the arrival of cold fronts. In the remaining instance a westerly wind was blowing. The following correlations between weather and migration were found to exist:

1. The arrival of a cold front invariably results in an arrested wave.
2. With the arrival of a cold front, migrants temporarily terminate their migration in the face of northerly winds, falling temperature, and rising barometric pressure.
3. The influx of migrants with the advent of a cold front is not immediate. Birds are present in maximum numbers on the day following the arrival of a cold front.
4. Southerly winds, rising temperature, and falling barometric pressure generally attend the departure of migrants.
5. In one instance westerly winds, which might tend to blow migrating birds out over the Gulf, had the same effect in pinning down migrants as the arrival of cold fronts.
6. Migrating birds were not seen to terminate their flight in the presence of strong tail winds.

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